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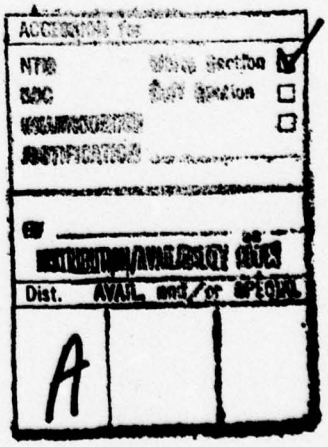

I SUMMARY

The broadband recording capabilities of the Seismographic Station of the University of California have been expanded to three stations, Berkeley (BKS), Jamestown (JAS), and Whiskeytown Dam (WDC). These stations provide ground motion data at two gain levels in the spectral range of 10 Hz to 100 sec. A library of broadband data is accumulating which is very useful in a wide variety of investigations. A body-wave surface wave discriminant at regional distances separates nuclear explosions from natural earthquakes, explosion collapses, and explosion aftershocks down to magnitude 3.5 in the western United States. The reason why this discriminant works is still not completely understood.

II INTRODUCTION

This is the final report for Grant No. AFOSR-73-2563 on "Broadband Discrimination Studies". The primary objectives of the research supported by this grant were as follows:

Expand the broadband recording capabilities of the Seismographic Station of the Univeristy of California.

Investigate the broadband spectral characteristics of both explosions and earthquakes at regional distances in the western United States.

Continue studies of regional explosion / earthquake discriminants in the lower magnitude range.

Develop a data base of broadband gound motion from both explosions and earthquakes at near and regional distances.

The following sections summarize the progress which has been made in the areas of research mentioned above. Many of the results have already been published and thus are readily avaliable so only the highlights of these studies will be presented here. Numerous references are made to the list of these publications contained in Section VII and to the seven technical reports that have preceded the present report.

III TECHNICAL DEVELOPMENTS

Over the years the Seismographic Station of the University of California has maintained a steady interest and a modest program in the recording of seismic ground motion over a very wide spectral bandwidth. These data have proved quite useful in studying earthquakes and nuclear explosions in the western United States. During the period of the present grant, these broadband recording capabilities have been both improved and expanded.

The development of a three-component broadband system at Berkeley (BKS) was completed and two new vertical component systems were installed at Jamestown in the central Sierra Nevada (JAS) and at Wiskytown Dam (WDC) in northern California. The response curves for these three systems are shown in Figure 1 and full technical details can be found in Technical Reports 2 and 3.

All three systems are recorded continuously on analog magnetic tape at two different gain levels with a bandwidth of 10 Hz to at least 100 sec. In some studies, data out to periods of 400 sec from the BKS system have been used successfully. Examples of these data from a regional earthquake, the Oroville earthquake of 01 August 1975, are shown in Figures 2 and 3. These examples illustrate the utillity of the dual gain feature, as a foreshock can be identified on the high-gain channel while the several mm of ground motion during the main shock can be maintained on scale on the low-gain channel.

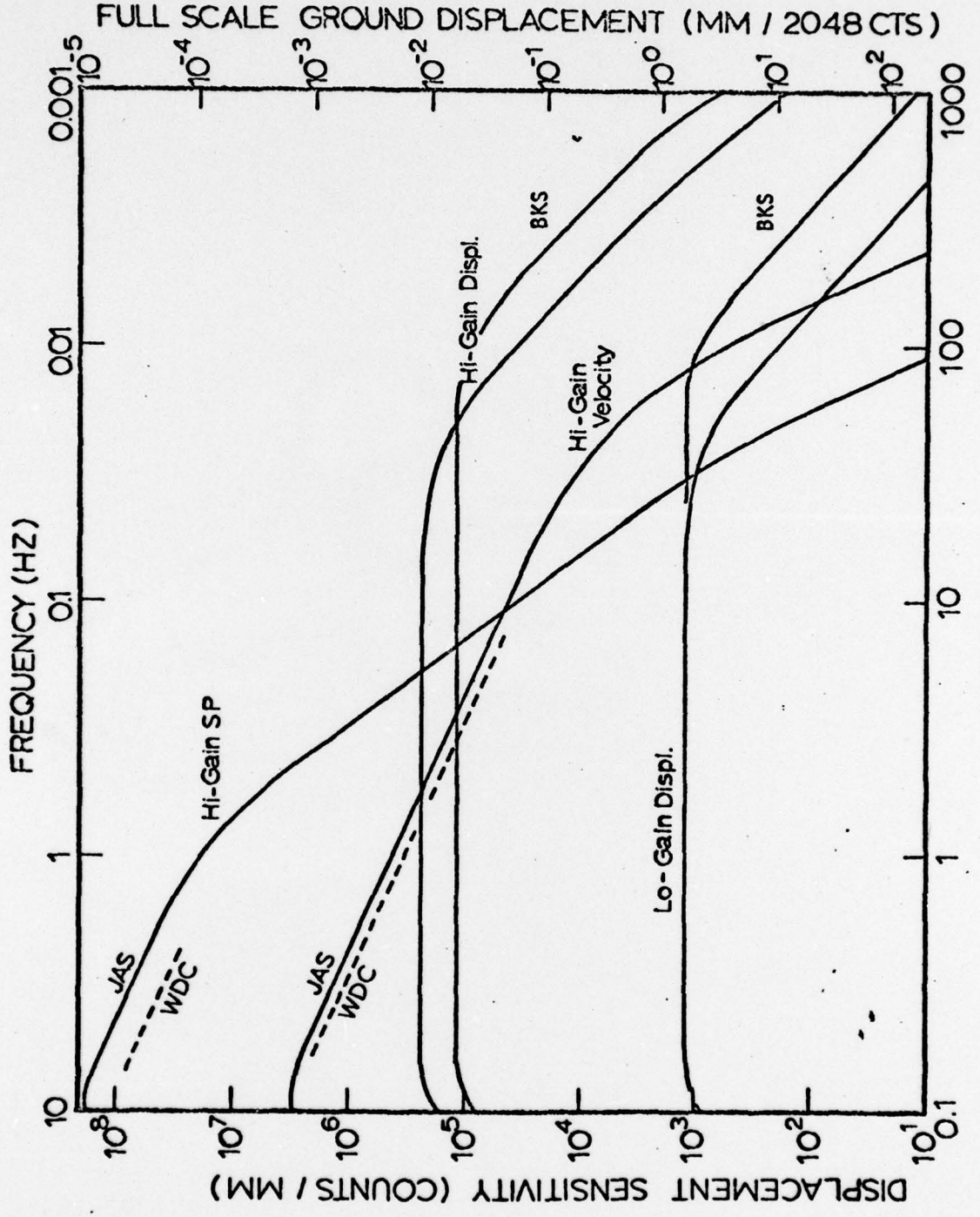
FULL SCALE GROUND DISPLACEMENT (MM / 2048 CTS)
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
0.001
0.01
0.1
1
10
100
1000
FREQUENCY (HZ)
PERIOD (SEC)
Hi-Gain SP
Hi-Gain Displ.
Hi-Gain Velocity
Lo-Gain Displ.
BKS
BKS
JAS
WDC
JAS
WDC
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
DISPLACEMENT SENSITIVITY (COUNTS / MM)

Figure 1.

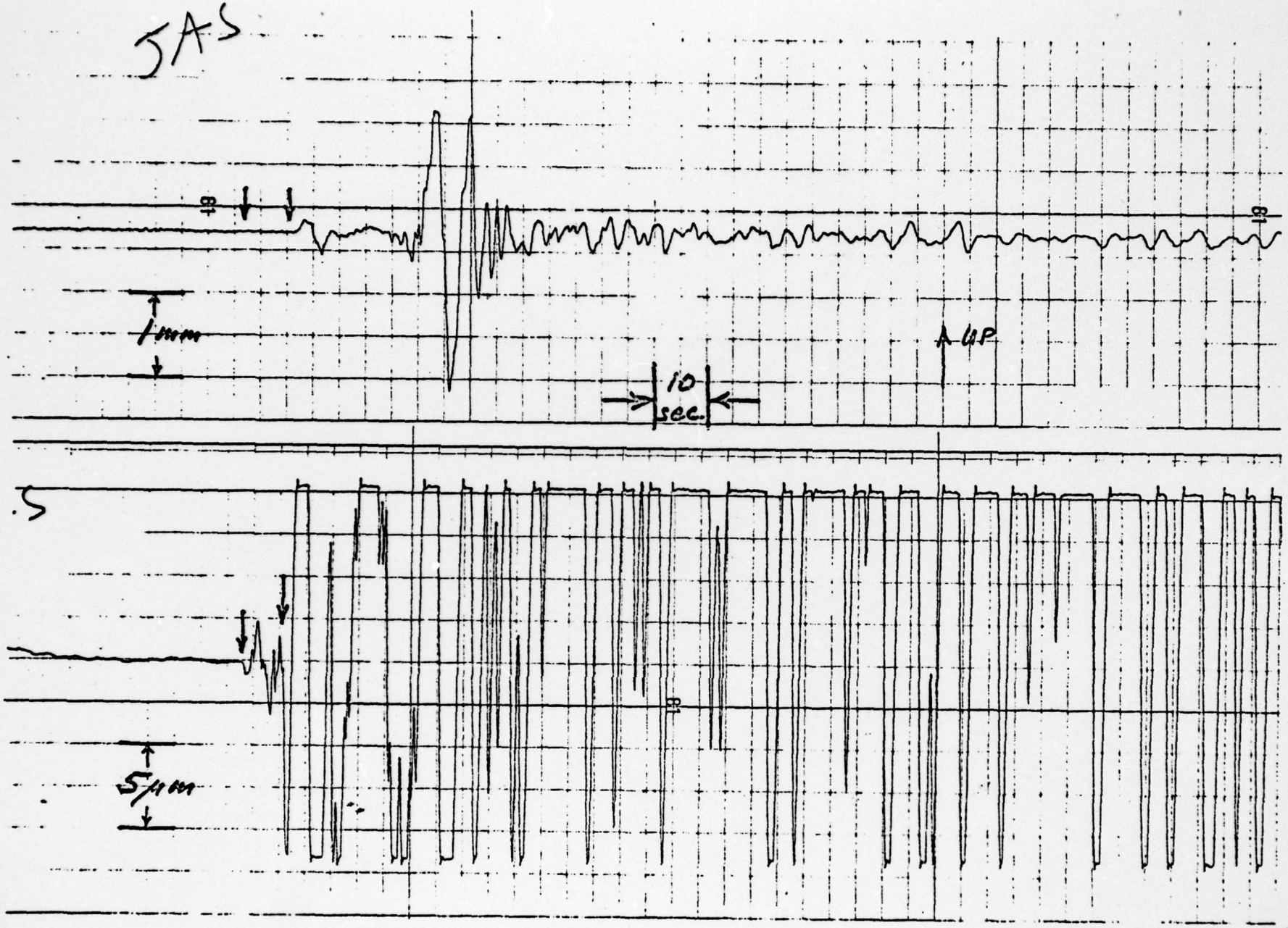

Figure 2. Broadband recordings of the 01Aug75 Oroville earthquake at JAS, vertical component. Low-gain (upper) channel is ±2mm full scale ground motion; high-gain channel is ±10microns full scale. Arrows indicate P-wave arrivals for foreshock and main shock.

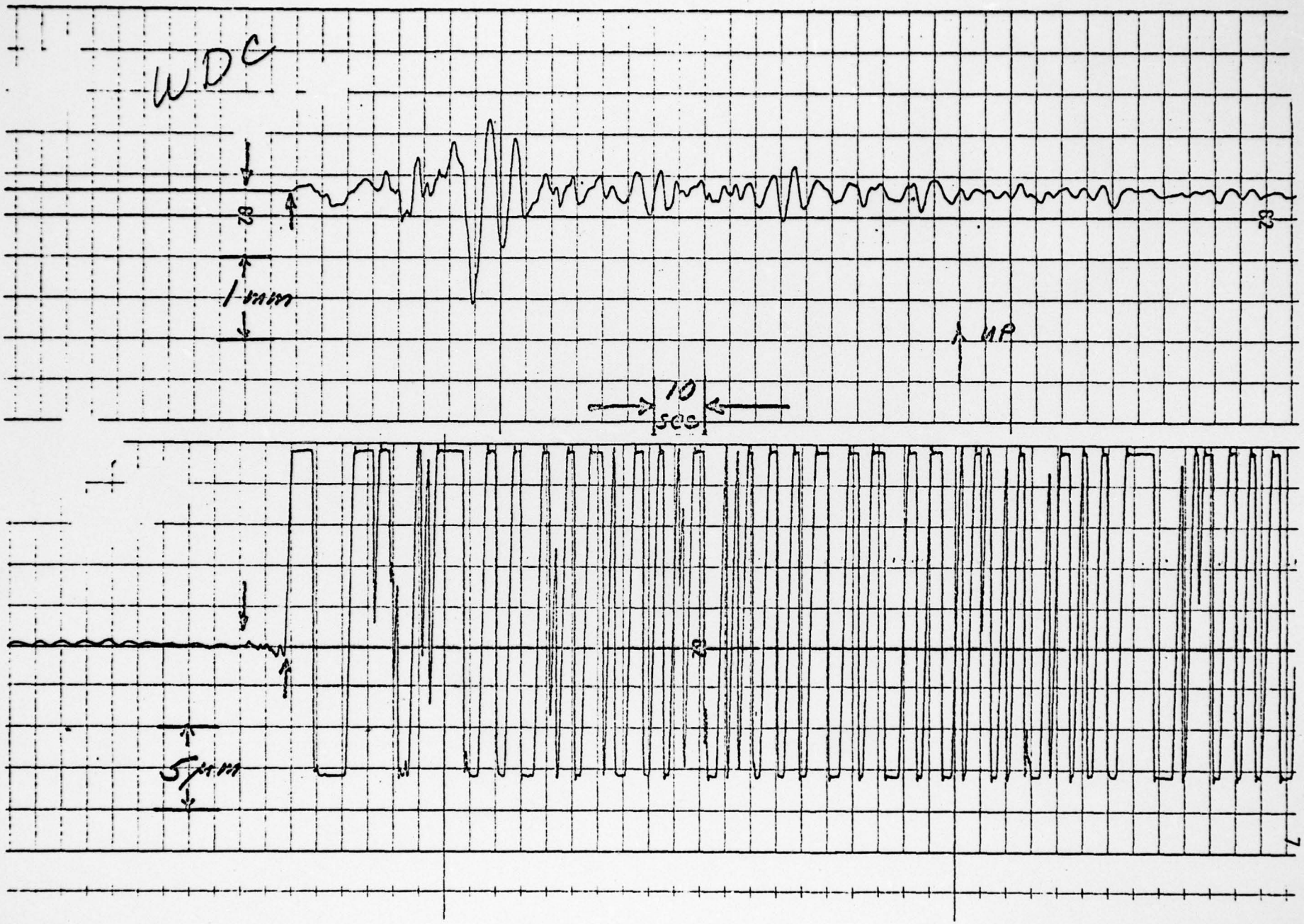

Figure 3. Same as Figure 8 but for WDC.

Several other aspects of seismic transducer design and stabilization were also studied (Dratler, 1974, 1976, 1977) and a 20 m quartz-tube strainmeter was brought into operation (Mortensen et al., 1977).

A considerable library of broadband data has been accumulated over the past few years, and, in addition to extensive useage by faculty and students at Berkeley, it is also being used more and more be investigators from outside the University of California. The digitization and analysis procedures for handling these data have also been undergoing a process of improvement and expansion and should soon be in a completed form.

IV EXPLOSION / EARTHQUAKE DISCRIMINATION

The Seismographic Station of the University of California, with its proximity to the earthquakes of California and Nevada and the explosions at the Nevada Test Site, occupies a favored location for the study of discrimination at near and regional distances. Because of this, studies of near and regional discriminants have been carried out at Berkeley for several years, and such studies have continued and been expanded during the tenure of the present grant.

One study (Peppin and McEvilly, 1974) showed that a body-wave surface-wave discriminant at regional distances separates nuclear explosions from natural earthquakes, explosion collapses, and explosion aftershocks. The discriminant was shown to work down to magnitude 3.5 with no indication of convergence of the populations at lower magnitudes. An exhaustive study was then undertaken to determine the underlying cause for the success of this discriminant (Peppin, 1974, 1975, 1976). While this study provided some interesting results concerning the source properties of explosions and earthquakes and reduced the number of potential causes, it did not solve the problem of why the discriminant works. Another study now underway (Stump and Johnson, 1977) will hopefully provide additional information about the processes occurring in the immediate vicinity of the explosion source. However, at the present time it appears that an effective discriminant exists for regional discrimination in the western United States, but the reason why the discriminant works is still not understood.

V EXPLOSION AND EARTHQUAKE SOURCE CHARACTERISTICS

The attack upon the discrimination problem has also been pursued on a very broad front through attempts to increase our understanding of the physical processes that are involved in both explosion and earthquake sources.

In one study (Bakun and Johnson, 1973) the explosions MILROW and CANNIKIN were studied at teleseismic distances and the method of homomorphic deconvolution was used to investigate the slapdown phase associated with near-surface spallation.

Another study (Johnson and McEvilly, 1974) investigated a series of earthquakes on the San Andreas fault by using broadband data recorded within a few km of the source. Properties such as fault-plane solutions, moments, and corner frequencies were all studied and a method of using synthetic seismograms to investigate source properties was introduced.

A study of earthquakes at regional distances (Peppin and Simila, 1976) found that the ratio of P to SV corner frequencies was approximately 1.0 and suggested this could be used to test various models of earthquake sources.

The source mechanism of the San Fernando earthquake of 1971 was studied by trying to fit the observed acceleration records with synthetic seismograms calculated for a propagating dislocation model of the earthquake (Litehiser, 1976).

The location, fault plane solution, and statistics of the foreshocks, mainshock, and aftershocks associated with the Oroville earthquake of August 1975 were studied (Morrison et al., 1976).

The general problems of time and space clustering of earthquakes was investigated with a comprehensive statistical treatment of a large number of small earthquakes in the San Andreas fault zone (Udias and Rice, 1975; Udias, 1977).

VI THEORETICAL AND COMPUTATIONAL DEVELOPMENTS

Progress in the general discrimination problem has depended to a certain degree upon the ability to handle some of the associated analytical and computational problems, and several advances in these areas have been made.

The complete solution for an arbitrary point source in a homogeneous halfspace has been tabulated in a form suitable for computation (Johnson, 1974). A method for using solutions such as these to obtain estimates of source properties has also been formulated (Stump and Johnson, 1977).

The importance of attenuation in wave propagation problems in the earth has recently received much attention. A method has been developed for incorporating anelastic effects in an exact manner into wave propagation in a layered halfspace (Silva, 1976, 1976, 1978).

VII REFERENCES

The following list contains the papers completed with total or partial support from this grant. It includes 17 papers published in refereed technical journals, 2 PhD theses, and 5 papers presented at meetings of scientific societies. In addition, a considerable amount of information, particularly on the technical details of the broadband recording systems, can be found in the seven previous technical reports for this grant.

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Morrison, P. W., B. W. Stump, R. Uhrhammer, The Oroville earthquake sequence of August 1975, Bull. Seism. Soc. Am., 66, 1065-1084, 1976.

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Stump, B., The determination of source mechanisms by the linear inversion of seismograms, paper presented at Fall Annual Meeting of the American Geophysical Union, 1976.

Stump, B. W., L. R. Johnson, The determination of source properties by the linear inversion of seismograms, Bull. Seism. Soc. Am., 67, 1489-1502, 1977.

Udias, A., J. Rice, Statistical analysis of microearthquake activity near San Andreas Geophysical Observatory, Hollister, California, Bull. Seism. Soc. Am., 65, 809-827, 1975.

Udias, A., Time and magnitude relations for three microaftershock series near Hollister, California, Bull. Seism. Soc. Am., 67, 173-185, 1977.

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